
Space Weather Technical Forecast

Issued on Sunday, 11 February 2024 at 13:37 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Current S1 conditions gradually declining. Further R1-R2 Radio Blackouts likely, with slight chance of R3. Chance of G1/G2 conditions day 2 (12 Feb), likely day 3 (13 Feb).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded at GOES16 has been Moderate over the past 24 hours, with a peak M9.0 flare, observed at 10/2307 UTC, originating from AR3576, which is located in the southwest quadrant. There are currently seven sunspot regions on the visible disc. AR3576 remains the dominant spot in terms of complexity and size, but has shown signs of fading and simplification in recent hours, with delta spots now very weak. AR3582 is the next most complex spot, which has continued to show minor growth in its intermediate spots. All other spots are relatively simple and unremarkable.

The M9.0 flare produced a full halo CME which preliminary modelling suggests will arrive around the middle of day 3 (13 Feb). Two further CMEs, visible emerging from the SE and SW limbs this morning on coronagraph imagery, await further analysis.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE and DSCOVR at L1, were at slow-ambient levels at first, below 400km/s, with density around average or below. The IMF (Bt) was weak at first, with the north-south component (Bz) varying weakly and the Phi angle was negative (towards the Sun).

A sudden increase in solar wind speed was observed around 11/0120UTC, to slightly elevated levels around 450km/s, gradually increasing further in recent hours to elevated levels around 550km/s. Density increased steadily to above average from around 10/2330UTC, with a sudden increase apparent at the same time as the speed increase around 11/0120UTC. The IMF (Bt) became strong at the same time, peaking at 19nT, with the north-south component (Bz) varying between -15 and +15nT, and the phi angle varying between positive (away from the Sun) and negative (towards the Sun). This is thought to be due to arrival of a CME, likely a glancing shock from the X-class flare on 09 Feb.

Geomagnetic activity was Quiet (Kp0-2) at first, but Active (Kp3) and Unsettled (Kp4) intervals have been observed since the sudden impact.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux remains above the S1 (10pfu) threshold, with a peak value of 187pfu observed at 10/1240 UTC, but has shown a declining trend after exceeding the S2 threshold twice over the last 24 hours.

GOES16 high energy (greater than 2MeV) electron flux remained at normal background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold and has had a flat trend, with a 11/0001UTC fluence value of 1.79e6 pfu observed.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate X-ray flare activity likely, and a slight chance of further X-class activity, with AR3576 providing the vast majority of the risk.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

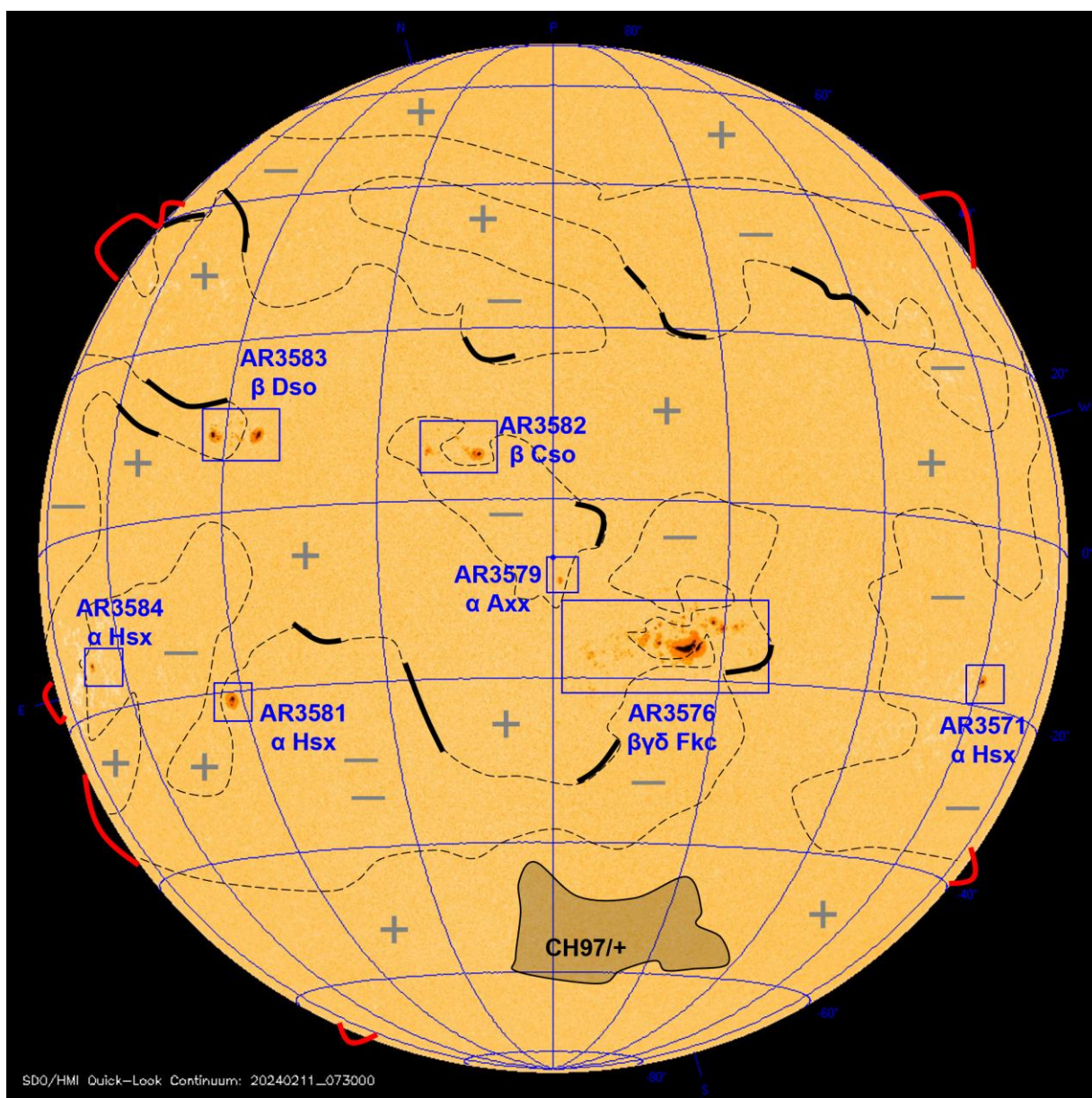
Solar Wind / Geomagnetic Activity: Multiple CME arrivals are possible over the coming days, particularly from late day 2 (12 Feb) and through day 3 (13 Feb), which may enhance the solar wind environment. No coronal hole fast winds are expected.

Quiet to Unsettled conditions are expected to start the four-day period. Chance of G1/G2 from late on day 2 (12 Feb) becoming likely into day 3 (13 Feb) due to multiple CME arrivals, with an outside chance of a G3. Lingering CME effects are possible by day 4 (14 Feb), though overall geomagnetic activity should fall back to Quiet to Unsettled, pending analysis of more recent CMEs.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux should begin to subside through the period, though likely remaining above S1 through day 1 (11 Feb), with a gradual fall to below S1 levels possibly by later day 2 (12 Feb).

High energy electron flux (greater than 2MeV) is expected to continue at current normal background levels, with the associated 24-hour electron fluence remaining well below the Active threshold.

Figure 1. Solar Analysis Valid 11/0730UTC.



Key: Filament — , Prominence — , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

There are multiple CMEs which currently feature in the forecast. The first is a CME associated with the 08/2030 UTC south-centre filament eruption. This is modelled as crossing 1AU, mainly behind and below the Sun-Earth line late on day 2 (12 Feb) or early on day 3 (13 Feb). The second is associated an eruption near south-centre disk associated with a potential filament disturbance and long period high-level C-class flare around 0700 on 10 Feb. This has been analysed as Earth-directed, possibly arriving during the first half of day 3 (13 Feb). The M9.0 flare late on 10 Feb, originating from AR3576, preliminary modelling suggests will arrive around the middle of day 3 (13 Feb).

Two further CMEs, visible emerging from the SE and SW limbs this morning on coronagraph imagery, await further analysis.

No coronal hole fast wind enhancements are expected within the forecast period, therefore the background solar winds should remain similar.

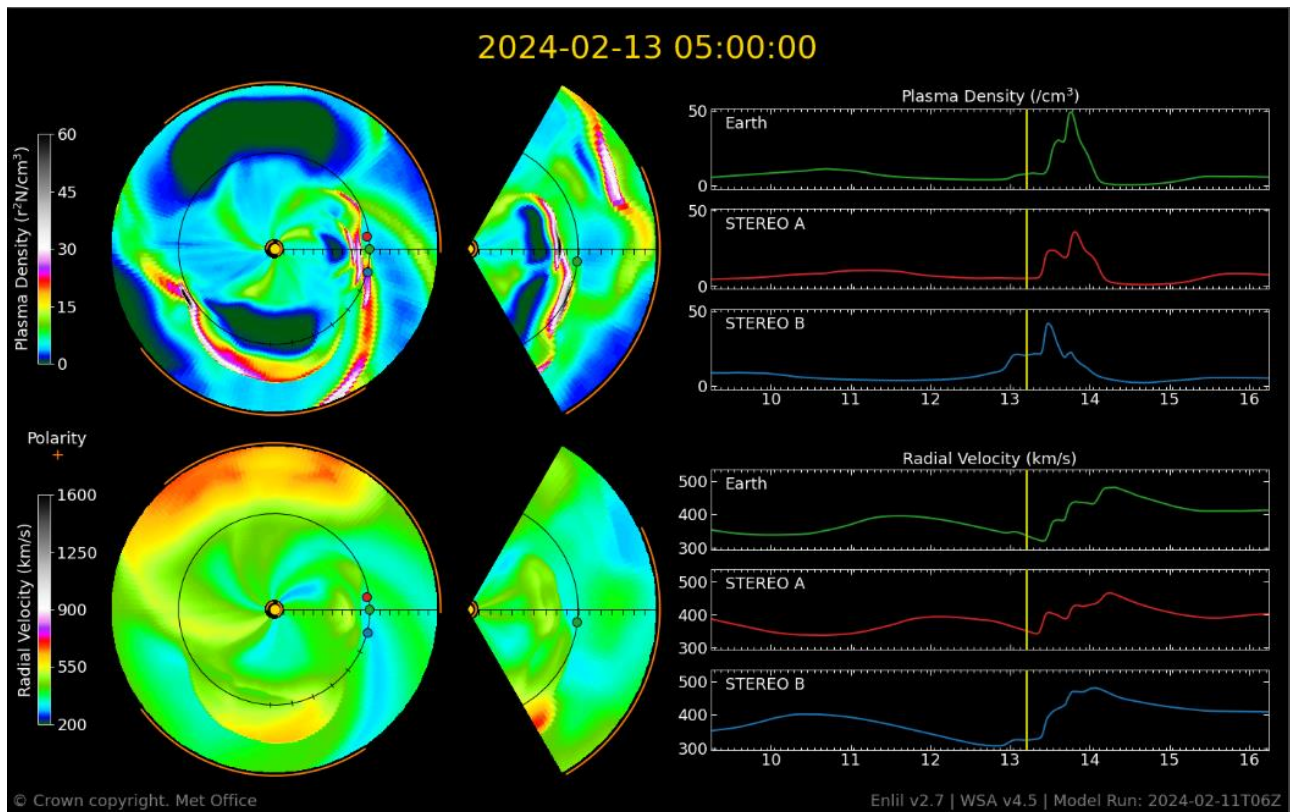
Quiet to Unsettled conditions are expected to start the four-day period, with waning effects from the arrival at 11/0120UTC. Chance of G1/G2 from late on day 2 (12 Feb) becoming likely into day 3 (13 Feb) due to multiple CME arrivals, with an outside chance of a G3 should all three possible CMEs arrive in quick succession. Lingering CME effects are possible by day 4 (14 Feb), though overall geomagnetic activity should fall back to Quiet to Unsettled, pending analysis of more recent CMEs.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	10	50	60	10
Strong	G3	No	1	5	2	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
08/2030	Partial	Filament Eruption	S centre	641 km/s	12/2300	Glancing blow
10/1058	Partial	Filament Eruption	S centre	930 km/s	13/1100	Direct hit
11/0306	Full Halo	M9.0 flare	AR3576, S centre	935 km/s	13/1600	Preliminary modelling

Figure 2: MOSWOC ENLIL showing multiple CME arrivals



Radio Blackouts - X-Ray Flares:

The risks of flare activity are now dominated by AR3576 near centre-disc.

The daily risk of significant flares is maintained through the period with further M-class flares considered likely from AR3576, and a slight chance of X-class. The returning Carrington locations for several past regions are due over the eastern solar horizon in the period - flaring from at least two regions is now visible in AIA94 over the eastern solar horizon, however any contribution from these regions will be assessed as and when they appear on the visible disc.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	No	20	20	20	20

Figure 3: GOES16/18 x-ray flux

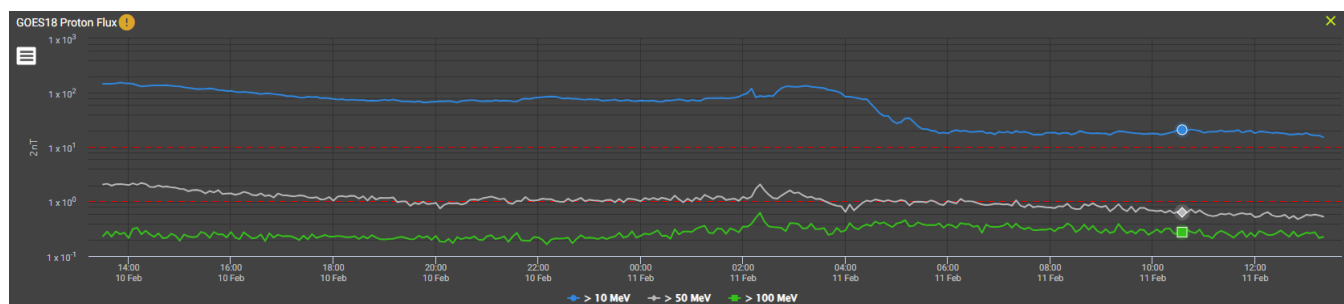


Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux is currently at S1 levels following the enhancement from the X3.3 flare from 09 Feb, associated with Ex-AR3575. The high energy proton flux should continue to subside through the period, though likely remaining above S1 through day 1 (11 Feb), with a gradual fall to below S1 levels possibly by day 3 (13 Feb). There will likely remain an elevated potential to rise above the S1/Minor Radiation Storm level in response to any significant flares from AR3576 as it rotates further into the western hemisphere through the period.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	Yes	99	80	40	30
Very Active	$\geq \text{S3}$ *	No	10	1	1	1
* $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)						

Figure 4: GOES18 Proton flux



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) as observed by GOES16 is expected continue at mainly normal background levels, given the expected absence of significant fast wind streams.

The associated 24-hour electron fluence is expected to remain well below the Active ($1\text{e}8$ integrated flux) threshold, as suggested by MOSWOC REFM, although the current forecast period is likely to move away from a predictable coronal hole fast/slow pattern and more towards a threat of CMEs given AR3576's position on the disc, rendering REFM less reliable.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	1	1
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1